Optimization of Groundwater Monitoring and Remedial Action Operation

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Overview

- Background
- Monitoring Optimization
  - Strategy
  - Case Studies
- RAO Optimization
  - Strategy
  - Case Studies
- Summary

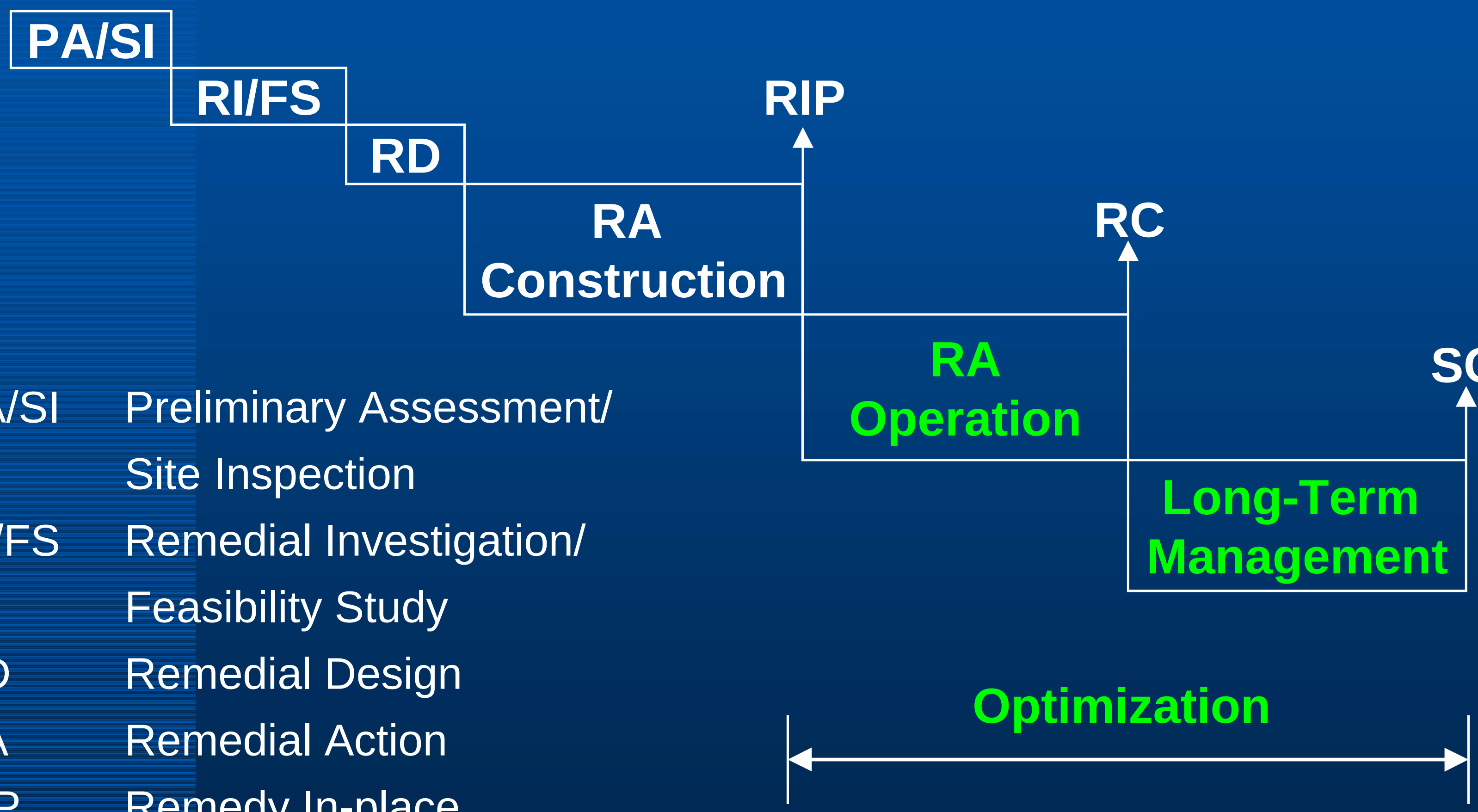
Why are Groundwater Monitoring and RAO Important?

- Installation Restoration (IR) Program Goal:

  "To achieve environmentally protective site closeouts at least cost."

- Site closeout is achieved through a series of phases or steps.
- Groundwater monitoring and RAO are key to the site closeout process.

IR Program Phases



PA/SI	Preliminary Assessment/ Site Inspection
RI/FS	Remedial Investigation/ Feasibility Study
RD	Remedial Design
RA	Remedial Action
RIP	Remedy In-place
RC	Response Complete
SC	Site Closeout

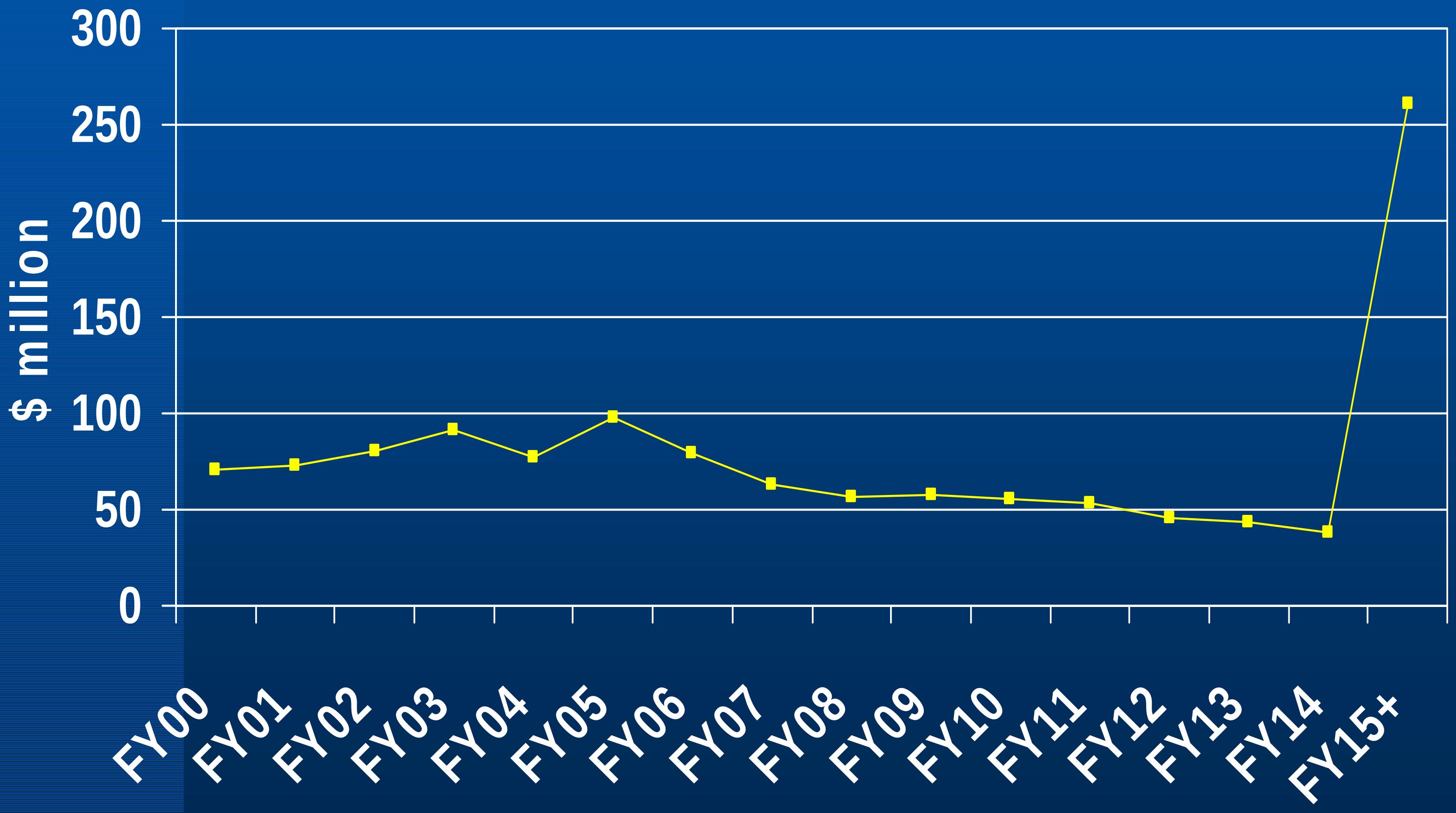
Groundwater Monitoring

- Validate the conclusions of RI/FS
- Determine if contamination is migrating
- Determine if contamination will reach receptor
- Assess remedial system performance
- Satisfy regulatory requirements
- Assess the practicability of achieving cleanup
- Confirm Response Complete
- Perform five-year reviews

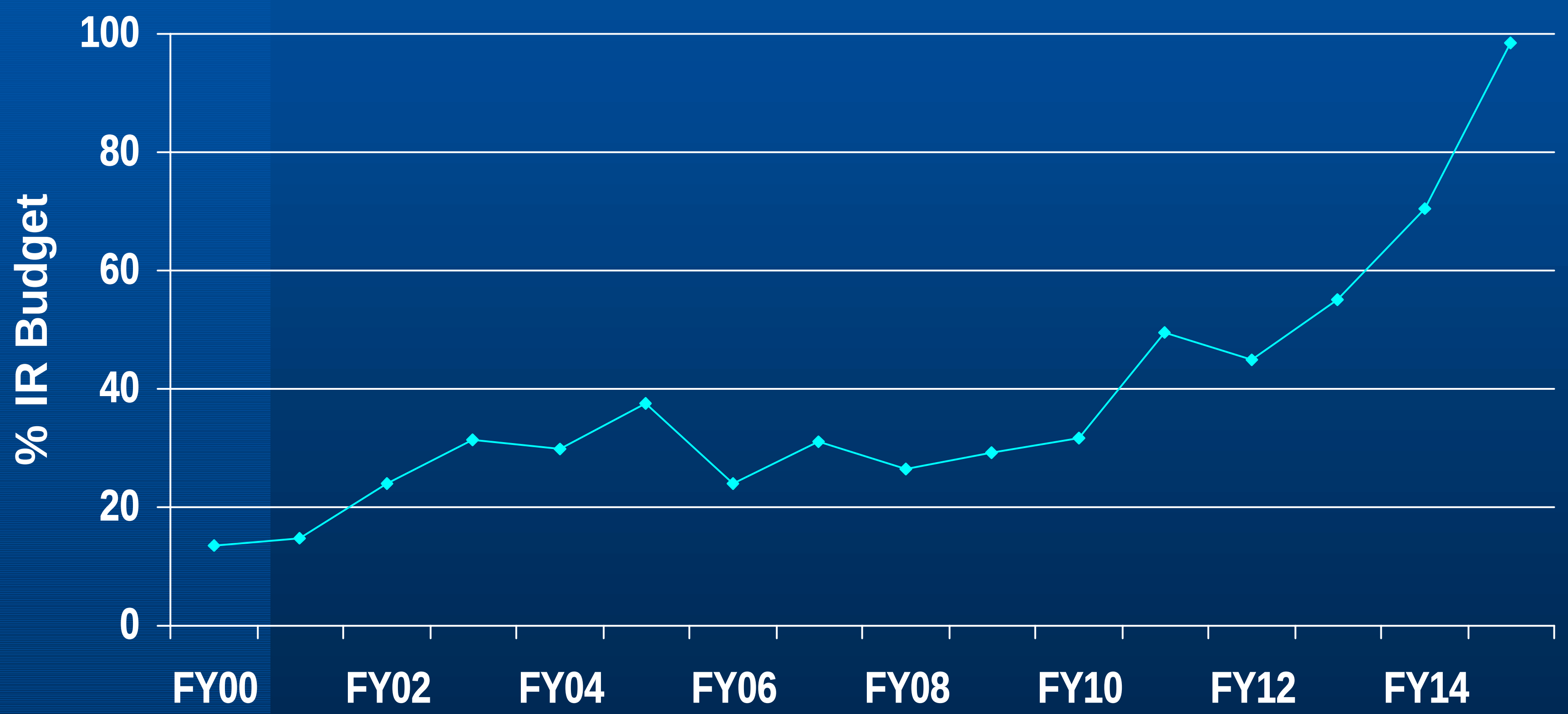
Remedial Action Operations

- Operate and maintain active remediation system
- Monitor progress of natural attenuation
- Monitor, evaluate, and optimize system(s):
  - Extraction system
  - Treatment system
  - Monitoring network/system
- Perform five-year reviews

RAO+LTM Budget Estimate
(NORM data September 1998)



RAO+LTM as Percent of DON IR Budget
(NORM data September 1998)



DON RAO/LTM Optimization Working Group

- DON Working Group formed in 1998 to develop guidance for optimizing monitoring and RAO
- "Optimization"
  - – Process to achieve optimal cost while maintaining or enhancing data quality and protectiveness.
- Approach
  - – Conduct case studies
    - - "In-house" - "Contractor"
  - – Develop guidance from lessons learned
- Members from NAVFAC, CNO, EFDs/EFAs, and NFESC

DON RAO/LTM Optimization Working Group

Mark Barnes	LANTDIV
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Debbie Felton	NORTHDIV
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Frank Peters	NAVFAC
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Ken Spielman	EFA West
Doug Zillmer	NFESC

Status: Case Studies and Guidance Documents

- Completed case studies for monitoring optimization
  - In-house: four sites
  - Contractor: six sites (three activities)
- Interim Final Monitoring Guidance – January 2000
- RAO case studies
  - In-house: three sites
  - Contractor: seven sites (four activities)
  - Site reports under review/revision
- Draft RAO Optimization Guidance – September 2000

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Monitoring Optimization

- Systematic and iterative process
- Groundwater (GW) Monitoring Plan
  - Monitoring goals
  - Exit strategy, decision criteria
  - Monitoring network, monitoring frequency, field procedures, analytical methods, quality assurance/quality control (QA/QC) procedures, data handling, and reporting procedures
- Site-specific or Basewide monitoring

Monitoring Optimization Strategy

- Six Elements
  1. Reducing number of monitoring points
  2. Reducing monitoring frequency
  3. Simplifying list of monitoring parameters
  4. Ensuring efficient field sampling procedures
  5. Streamlining data evaluation and reporting
  6. Performing annual evaluation

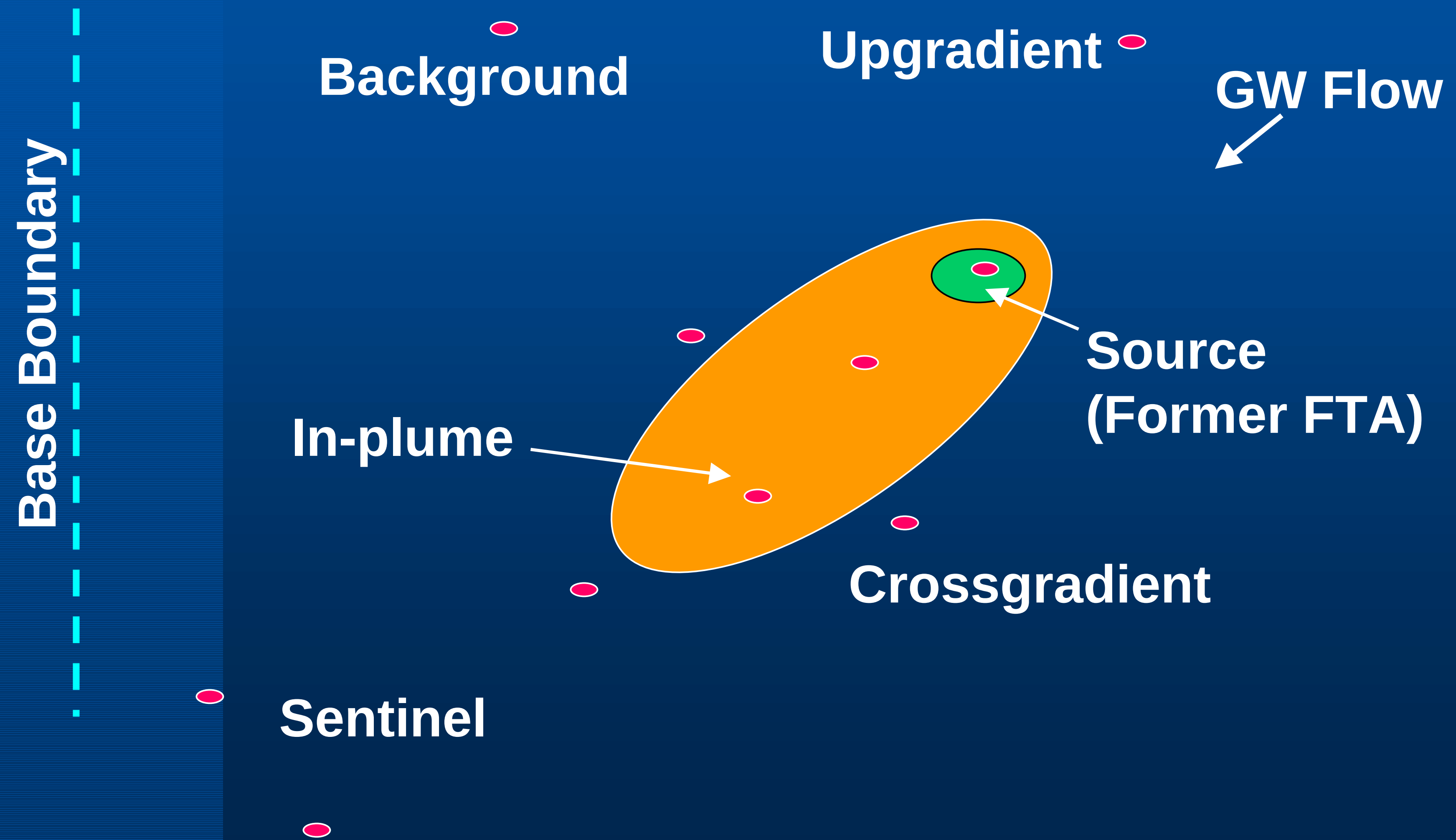
1. Reducing Number of Monitoring Points

- Largest impact for reducing costs
  - Labor
  - Lab analysis
  - Data management
  - Reporting
- Typically, more wells than necessary are monitored
- Need to comply with state requirements
- Need to monitor horizontal and vertical extent

1. Reducing Number of Monitoring Points (Cont.)

- Common monitoring wells:
  - Upgradient
  - Source area
  - In-plume
  - Crossgradient
  - Plume edge
  - Sentinel/point of compliance

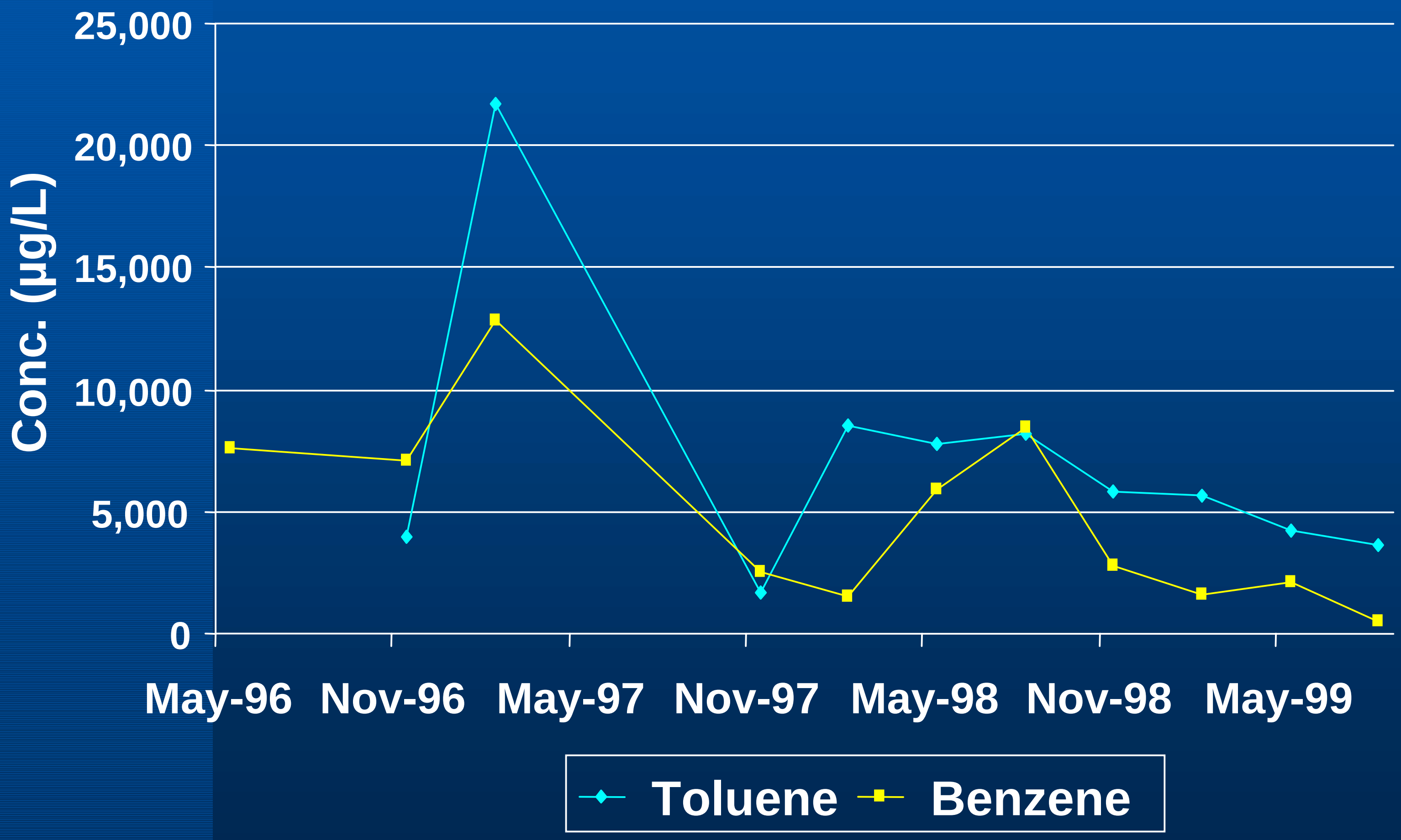
Idealized Monitoring Well Network



1. Reducing Number of Monitoring Points (Cont.)

- Perform annual review to see if well is needed
- Evaluate decision criteria
- May need wells for water-level monitoring only
- For large sites or Basewide application, may use geostat to determine redundancy
- Construct time series plots for visualizing contaminant trends

Example Time Series Plot – Air Sparging/Soil Vapor Extraction (AS/SVE) Site



2. Reducing Monitoring Frequency

Considerations:

- Conduct quarterly monitoring for first year
- Evaluate site to reduce monitoring to semiannual or less
- Sample background and upgradient wells less frequently
- Use simple groundwater flow calculations to estimate contaminant migration rate
- Construct trend plots (time series)
  - If concentrations do not change rapidly, reduce frequency

2. Reducing Monitoring Frequency (Cont.)

- If simple trend analysis is not helpful, use statistical trend analysis (Mann-Kendall test) or regression analysis
- Evaluate decision criteria
- Frequency and duration of monitoring will depend upon ongoing remedial action

3. Simplifying List of Monitoring Parameters

- Initial rounds typically contain a large number of sampling parameters
- After year 1, reduce parameters to contaminants of concern (COCs)
  - Savings for data management, data validation, and reporting
- Elimination of metals as COCs
  - Compare to background levels
  - Use low flow sampling
- Reduce number of QA/QC samples

4. Ensuring Efficient Field Sampling Procedures

- Low flow sampling technique
  - Sample from discrete zone
  - Decreases investigation-derived waste (IDW)
  - Reduces turbidity → Reduces total metal concentrations
  - May reduce labor
  - Evaluate applicability for each site
- Dedicated vs. non-dedicated pumps & sampling equipment – need to evaluate

4. Ensuring Efficient Field Sampling Procedures (Cont.)

- Diffusion samplers
  - – New technology developed over last few years
  - – Potential for reducing costs significantly
  - – Protocol being developed by DON/USAF/USGS/ITRC
  - – Used/tested at Navy sites
    - NSA Mid-South (RPM News, Summer 1999)
    - http://enviro.nfesc.navy.mil/ps/newsletters/rpm/1999su.pdf
  - – Measures volatile organic compounds (VOCs) only
  - – Regulatory acceptance?
  - – Sampling costs (NSA Mid-South): $1 to $7 per well using diffusion samplers; $34 to $118 per well using low flow purging technique

Commercially Available Diffusion Sampler Assembly

Hanger

Polyethylene Bag &
Outer Protective Mesh

Weight

5. Streamlining Data Evaluation and Reporting

- Data Evaluation/Interpretation
  - Time series plots, box plots
  - Trend analysis, other statistical analysis
  - Cost and performance plots
  - Data tables
  - Geographic Information System (GIS) for spatial data display, plume maps
  - Custom databases

5. Streamlining Data Evaluation and Reporting (Cont.)

- Report streamlining
  - Quarterly/semiannual reports
    - Mostly data and results
  - Annual reports
    - Text, detailed data analysis, results, and recommendations

6. Performing Annual Evaluation

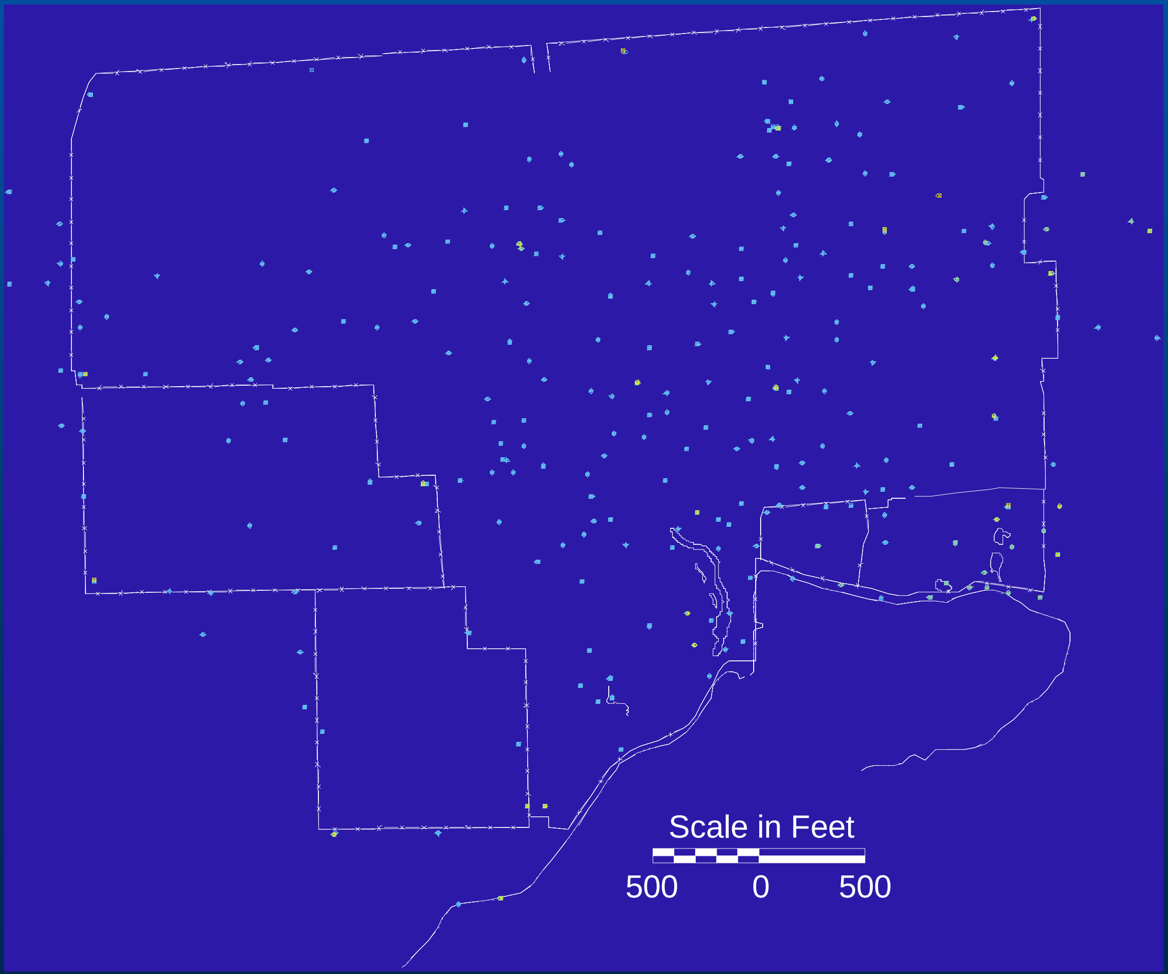
- Integral part of monitoring program
- Need to look at entire program, including data quality objectives (DQOs), decision criteria, and cleanup goals
- Annual report formalizes evaluation
  - Provides and tracks optimization recommendations
  - Provides information for five-year reviews

Case Studies

- Several case studies were performed
  – In-house
  – Contractor
- Lessons learned are used for guidance document
- Case studies are available on RAO/LTM Web site:
  – http://enviro.nfesc.navy.mil/ps/raoltm/index.html

Case Study: Naval Weapons Industrial Reserve Plant (NWIRP) Dallas, TX Monitoring Optimization

- NWIRP covers about 300 acres
- VOC plumes cover 80% of installation
- About 300 wells installed for characterization
- State requires a Basewide GW compliance plan



Case Study: NWIRP Dallas, TX Monitoring Optimization – Iterative Process

- 1994 monitoring round ~ 140 wells
- 1997 monitoring round ~ 200 wells
- SOUTHDIV/NWIRP actions to optimize monitoring
  - Used geostat in 1997 to identify 52 redundant wells
  - Conducted background study for metals
  - Used low flow sampling
    - Eliminated metals in GW samples for many wells
  - Used custom database for data management

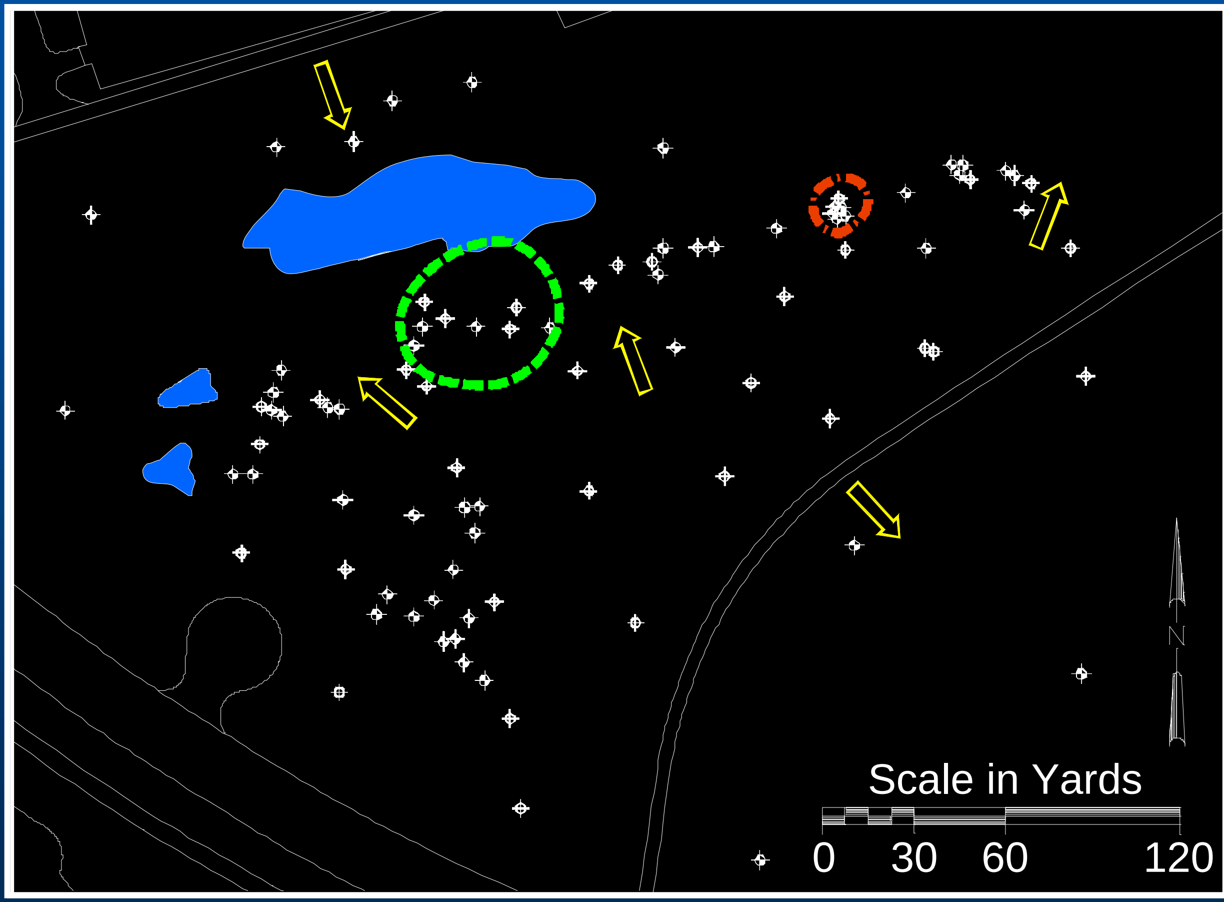
Case Study: NWIRP Dallas, TX Monitoring Optimization – Iterative Process (Cont.)

- Case study recommendations
  - Include 66 wells (may need additional wells for future RA)
  - Analyze for selected VOCs (11) instead of entire suite (41)
  - Conduct quarterly sampling for one year, then evaluate for semiannual/annual sampling
  - Conduct annual review to evaluate monitoring program against criteria

Case Study: Fuel Farm, NAS Patuxent River, MD

Case Study: Fuel Farm, NAS Patuxent River, MD

- 12-acre site
- 90 monitoring wells
- Petroleum spills and leaks and on-site tank bottoms disposal
- Two plumes
  - Free-phase product
  - Benzene >100 ppb

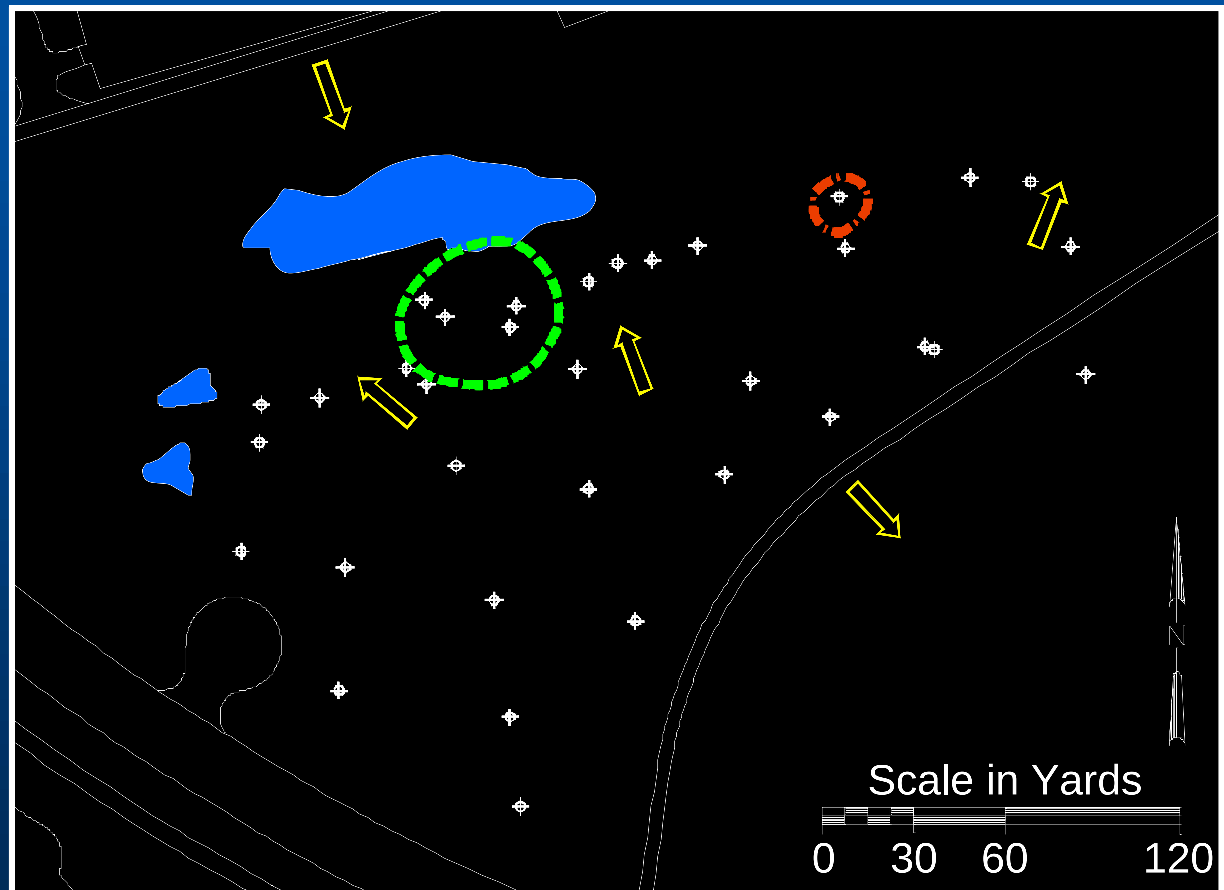


Free-phase product plume
Benzene plume
Groundwater flow direction
Surface water

Case Study: Fuel Farm, NAS Patuxent River, MD

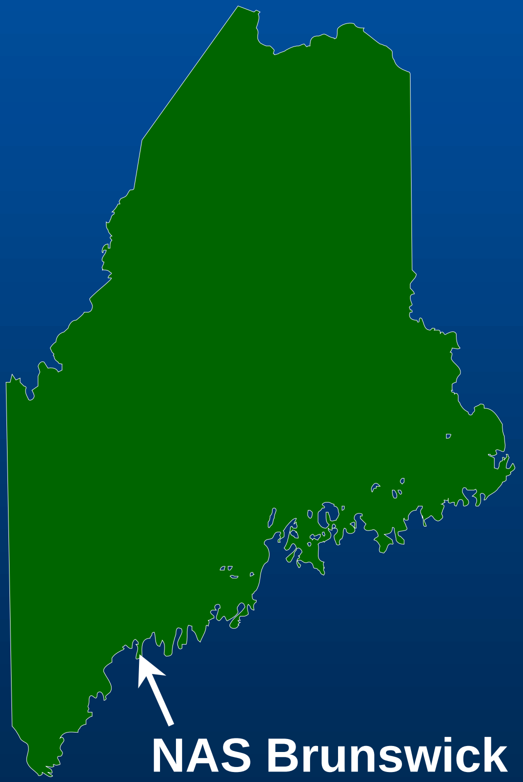
Recommendations

- Include 34 monitoring wells
- Conduct quarterly sampling for one year, evaluate for semiannual/annual sampling
- Include BTEX analysis in addition to TPH
- Conduct annual review to evaluate program



Free-phase product plume
Benzene plume
Groundwater flow direction
Surface water

Case Study: NAS Brunswick, ME



Case Study: NAS Brunswick, ME
Monitoring Optimization at Eastern Plume

- What prompted Navy to review monitoring program?
  - Data review and geostat showed redundant and predictable data
  - High cost
    - $550K per year
- How were optimization decisions made?
  - Navy, U.S. Environmental Protection Agency (EPA), and Maine Department of Environmental Protection (MDEP) met for three days
  - Reviewed trends at each sampling location, using DQO

Case Study: NAS Brunswick, ME
Monitoring Optimization at Eastern Plume (Cont.)

- What was achieved?
  - Monitoring frequency reduced from three to two times per year
  - Number of wells reduced from 36 to 22
  - Five new wells installed to fill data gaps
  - Reports streamlined
    - Monitoring reports contain mostly data
    - Annual report includes detailed discussion
    - Monitoring reports on CD-ROM – reduced number of hard copies
  - Cost reduction ~ $225,000

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RAO Optimization

- Evaluate progress toward cleanup goals
- Ensure remedy is:
  – Operating properly
  – Protective
  – Cost-effective
  – Capable of achieving cleanup goals
- Collect data/information for five-year reviews
- Achieve Response Complete timely and cost-effectively

Remediation Technologies for Case Studies

- DON Working Group members identified sites for case studies
- Completed
  - Pump and Treat (P&T) – Five systems
    - Chlorinated VOCs
    - Petroleum
    - Aboveground treatment: air stripping, granular activated carbon (GAC) and ultraviolet (UV)-chemical oxidation
- In progress
  - AS/SVE and bioslurping systems

Remediation Technologies for Case Studies (Cont.)

- Completed
  - In-house
  - In situ chemical oxidation (SOUTHDIV presentation)
- In progress
  - In-house
  - Remote monitoring of multi-phase extraction system

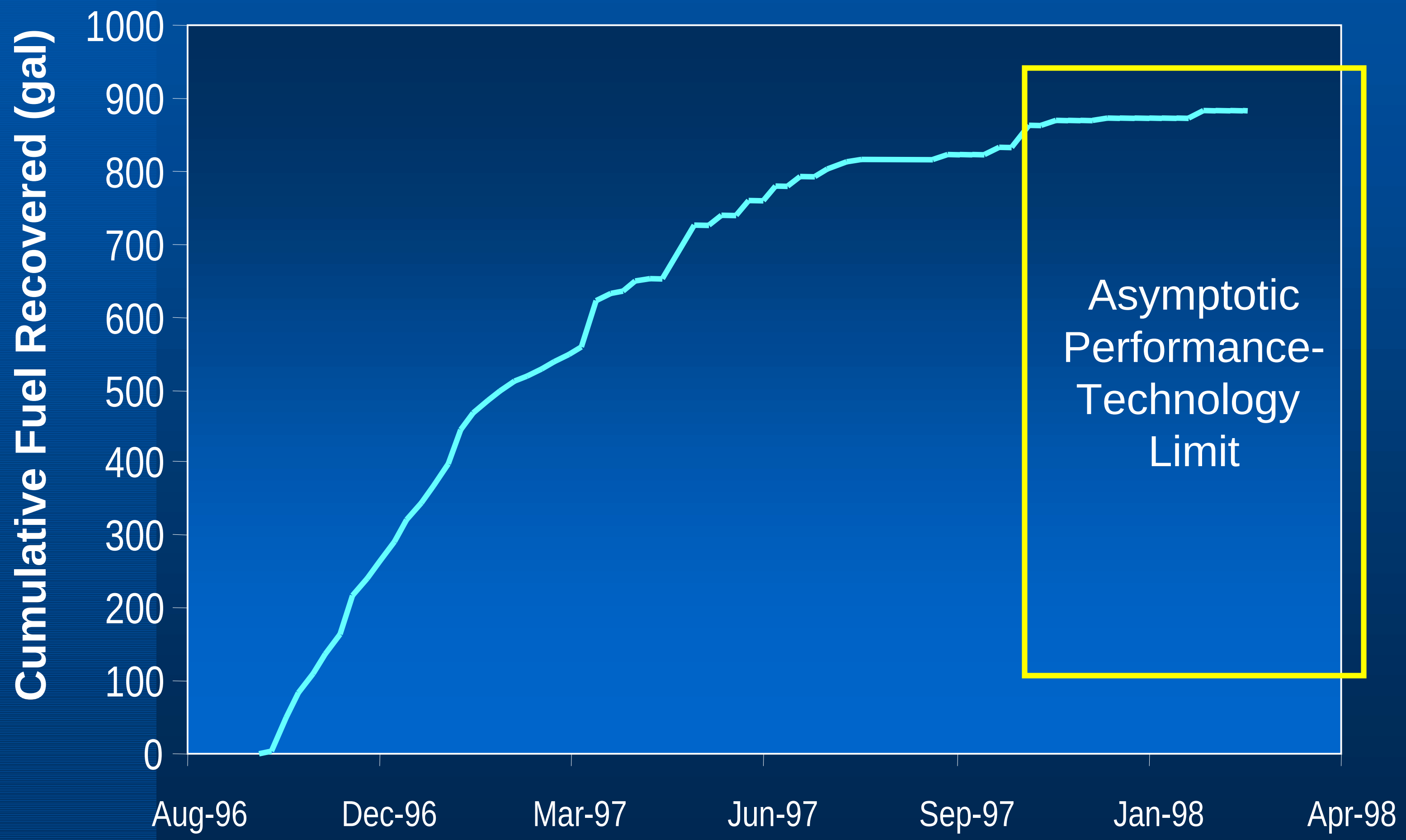
RAO Optimization Strategy for Case Studies

- Review site background
  - Site description
  - Regulatory framework
  - Site conceptual model
- Evaluate System Performance
  - Cost and performance plots
  - Extraction and monitoring network
  - Aboveground treatment train

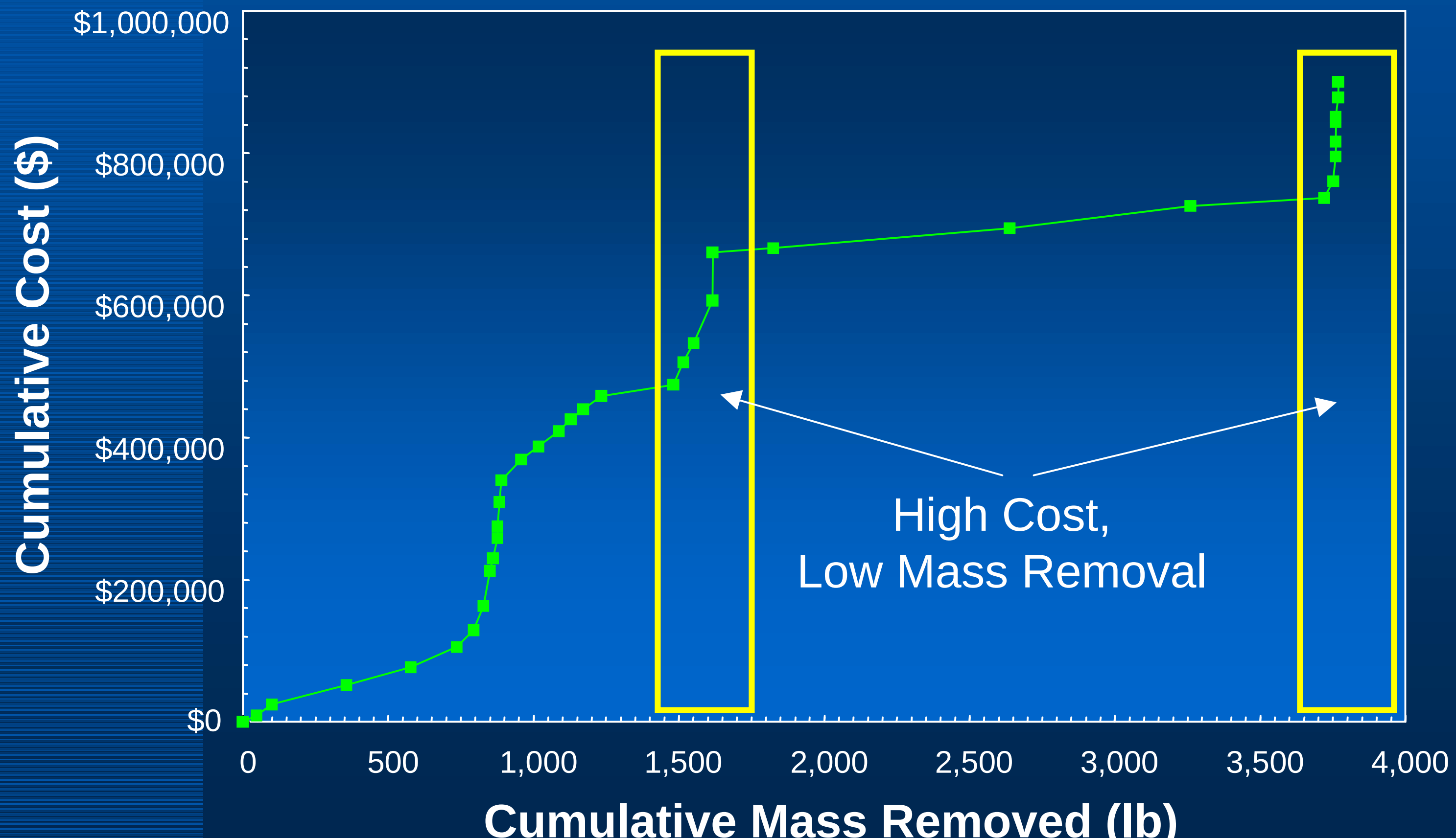
RAO Optimization Strategy for Case Studies (Cont.)

- Recommendations
  - Improving existing system
    - Extraction and monitoring network
    - Treatment system
  - Cleanup requirements
  - Additional or alternative remediation technologies

Performance Plot: Bioslurper Fuel Recovery



Cost & Performance: AS/SVE System
Cumulative Cost vs. Mass Removed



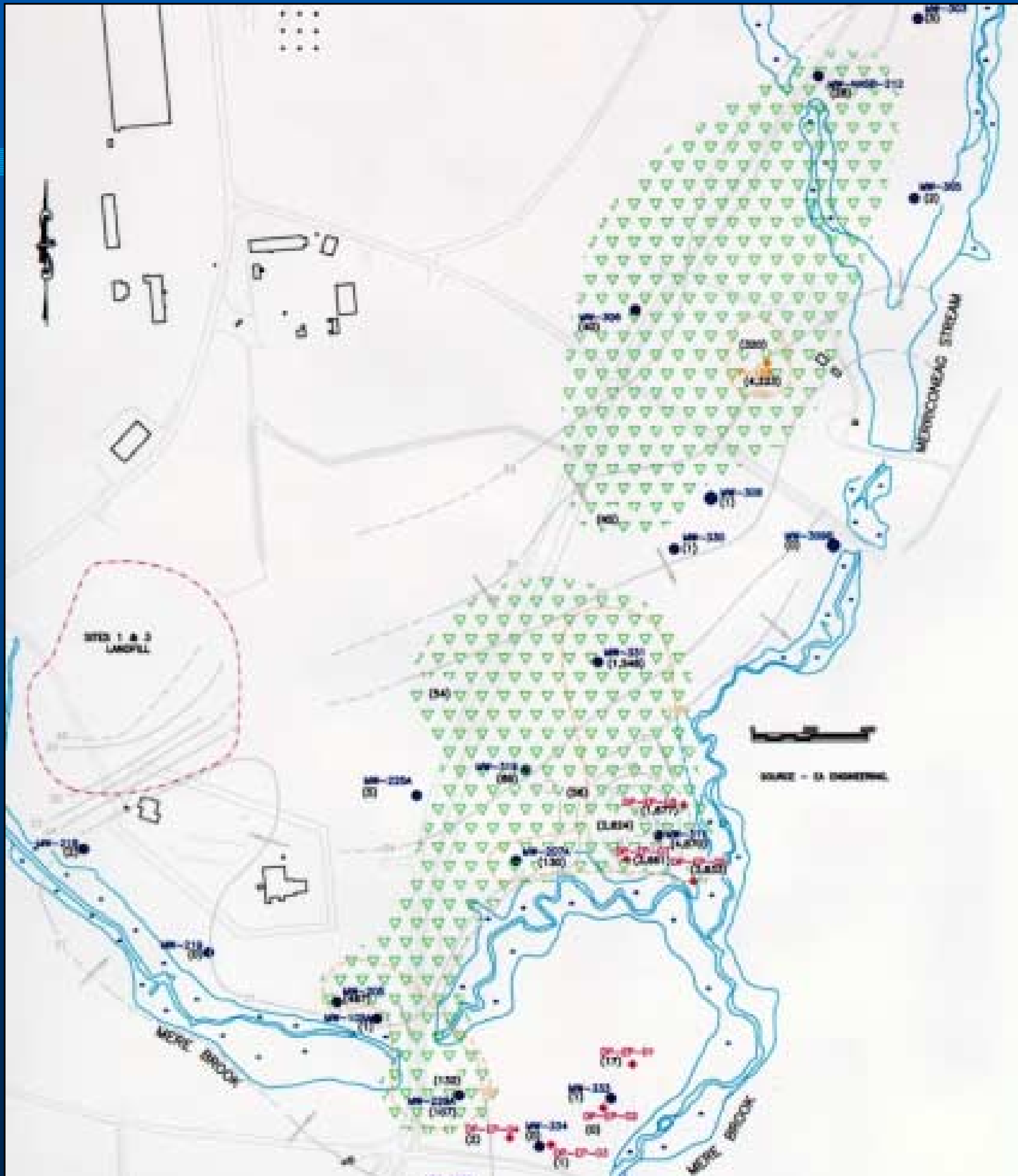
Case Study: NAS Brunswick, ME

RAO Optimization at Eastern Plume

- Plume originated from three sites
  - Acid/caustic pit
  - Former FTA
  - Defense Revitilization Marketing Office (DRMO)
- Chlorinated VOCs
  - 1,1,1-TCA, TCE, PCE, 1,1-DCE, etc.
- Interim ROD 1992; Final ROD 1998
  - P&T system to contain, remove, and treat contaminants
  - Includes language for monitored natural attenuation (MNA) to achieve site cleanup
  - Cleanup levels: State of Maine guidelines – TCA (200 ppb), TCE (5 ppb), PCE (5 ppb), 1,1-DCE (7 ppb)

Case Study: NAS Brunswick, ME
RAO Optimization at Eastern Plume (Cont.)

- P&T system started in 1995
  - Five extraction wells for eastern plume
  - Two wells for landfill dewatering
  - Treatment system includes:
    - Metals precipitation (for landfill GW)
    - Clarification/filtration
    - UV-chemical oxidation for VOCs
- Landfill dewatering is complete
  - Extraction wells and leachate treatment system is now standby



Case Study: NAS Brunswick, ME

Eastern Plume: Total VOCs in Deep Groundwater

Case Study: NAS Brunswick, ME
Mere Brook

- Located downgradient of eastern plume
- No VOC discharge to Mere Brook
  - Determined by MDEP/EPA study
- Water samples also show no VOCs

Case Study: NAS Brunswick, ME
Groundwater Treatment

- UV-chemical oxidation reactor
- UV lamps inside tubes
- Hydrogen peroxide added to GW
- No off-gas treatment
- Limited effectiveness for trichloroethane (TCA)

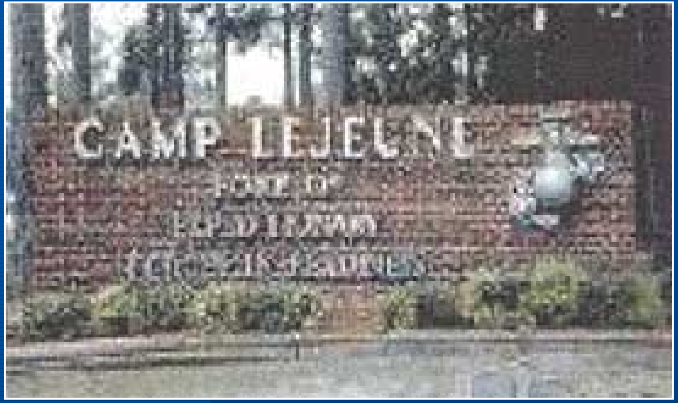
Ongoing Optimization Practices
(NORTHDIV & NAS Brunswick)

- Added a new extraction well
  - Short screen interval, deeper zone only
  - Improved contaminant mass removal
  - Improved well design and placement
- Completed evaluation of aboveground treatment system
  - Recommended replacing UV-chemical oxidation system with an air stripper
- Evaluated effluent discharge options to avoid sewer discharge fees

Case Study: NAS Brunswick, ME
Recommendations

- Case study provided a “second look”
  - Agreed with ongoing optimization practices
- Recommendations
  - Start study for monitored natural attenuation (MNA) evaluation
  - Initiate negotiations with regulatory agencies for risk-based cleanup levels (RBCLs)
  - Implement minor changes in sampling and monitoring
  - Reduce treatment plant operation labor cost
  - Operate extraction wells at hot spots until asymptotic levels are reached

Case Study: MCB Camp Lejeune, NC



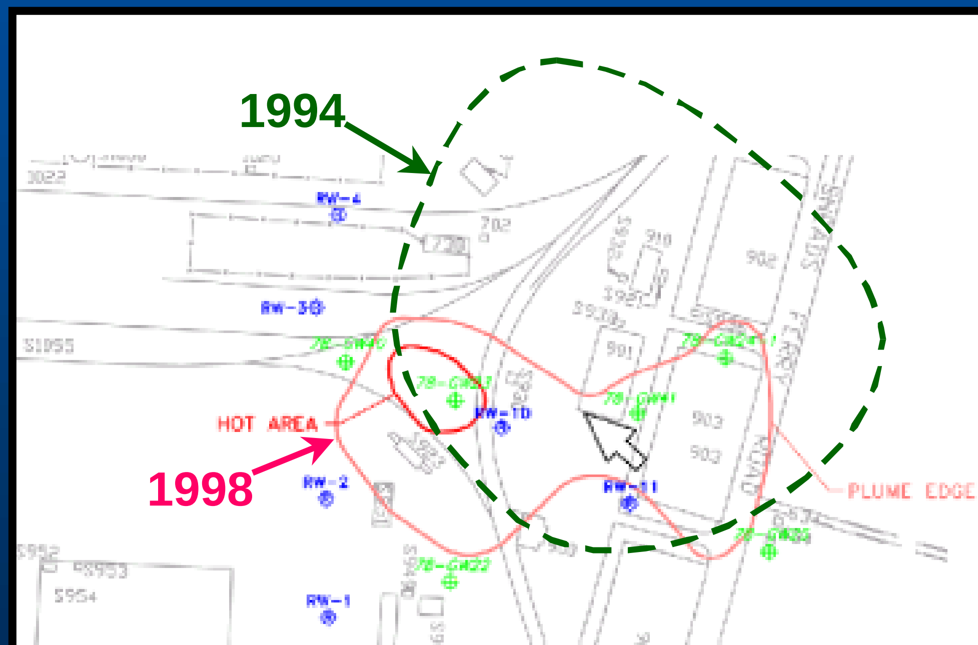
Case Study: MCB Camp Lejeune, NC
Operable Unit (OU) 1

- Three sites, GW contamination from Site 78 (Hadnot Point Industrial Area [HPIA])
  - North and south plumes
  - VOCs in shallow aquifer: PCE, TCE, VC, 1,2-DCE, benzene, etc.
- ROD signed 1994
  - North and south P&Treat systems
  - Cleanup levels
    - Combination of maximum contaminant levels (MCLs), NC state regulations, and RBCLs
    - PCE (0.7 ppb), TCE (2.8 ppb), VC (0.015 ppb), 1,2-DCE (total) (70 ppb), benzene (1 ppb)

Case Study: MCB Camp Lejeune, NC
OU 1 (Cont.)

- P&T systems started in 1995
  - Identical treatment trains
    - Pretreatment
    - Air stripping
    - GAC
  - Current extraction wells
    - Three north
    - Seven south
- Extraction well network upgraded in 1998
- Low-permeability aquifer impedes mass removal by GW extraction

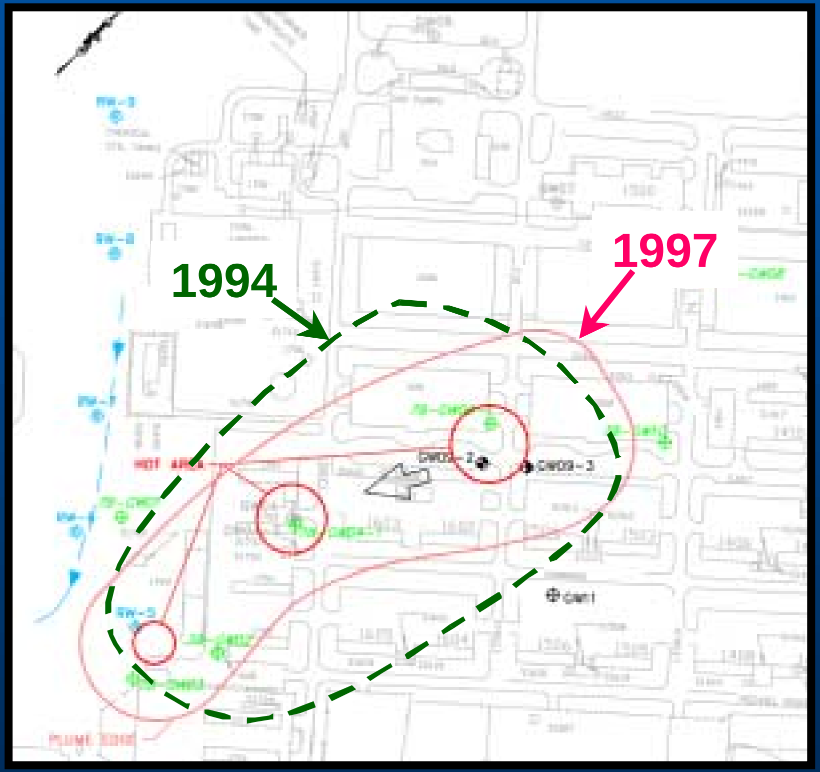
Case Study: MCB Camp Lejeune, NC
OU 1 North Plume: Total VOCs



Plume: 10 ppb
Hot Spot: 10,000 ppb

Case Study: MCB Camp Lejeune, NC

OU 1 South Plume: Total VOCs



Plume: 10 ppb
Hot Spot: 10,000 ppb

Case Study: MCB Camp Lejeune, NC
OU 1: Recommendations

- Continue operating P&T systems until recovery rates reach asymptotic levels
- Conduct MNA evaluation study
  - Breakdown products are present
  - Plumes appear to be contained
  - No receptor impacted
  - May need additional monitoring wells

Case Study: MCB Camp Lejeune, NC
OU 1: Recommendations (Cont.)

- Consider revising risk assessment assumptions to industrial land-use scenario
- Continue to monitor in accordance with GW monitoring plan
- Evaluate use of air stripper without GAC polishing, and GAC without air stripping
- Prepare time series plots for individual COCs

Case Study: MCB Camp Lejeune, NC
OU 2

- Three sites, 210 acres
  - Current GW contamination mostly from Site 82 (storage lot)
- Chlorinated VOCs in shallow and deep aquifer
  - PCE, TCE, 1,2-DCE, VC, etc.
- Deep aquifer is drinking water source
- ROD signed 1993
  - Selected remedies: soil removal, SVE, and P&T
  - Cleanup levels
    - Combination of MCLs, NC state regulations, and RBCLs
    - PCE (0.7 ppb), TCE (2.8 ppb), 1,2 DCE (total) (70 ppb), VC (0.015 ppb)

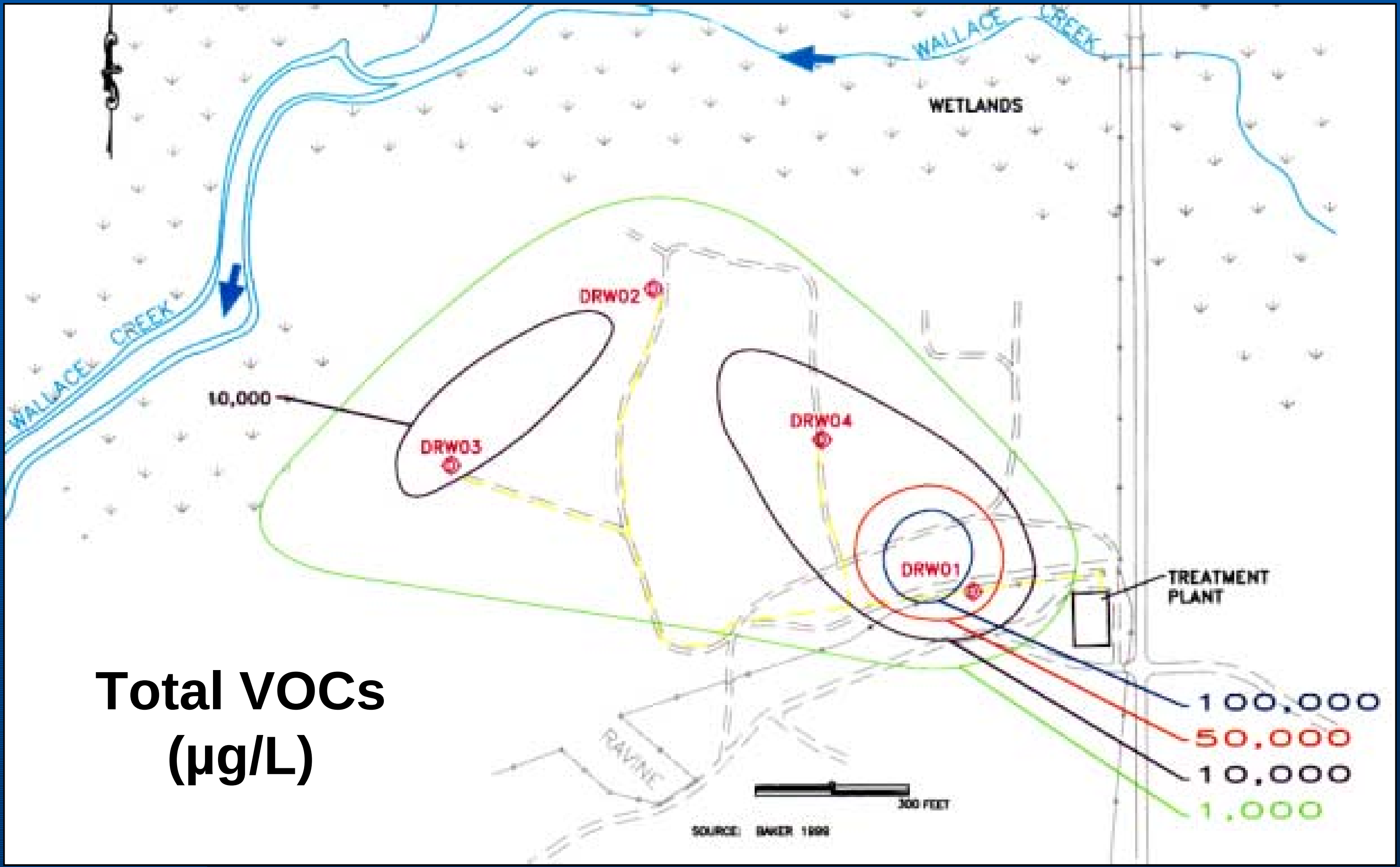
Case Study: MCB Camp Lejeune, NC
OU 2 (Cont.)

- P&T systems started in 1996
  - Large system ~300 gpm
    - Pretreatment, air stripping, GAC
  - Current extraction wells
    - Six shallow – 35 ft, 4 to 8 gpm per well
    - Four deep – 101 to 154 ft, 30 to 150 gpm per well
- System operates at high efficiency
- Removed 41,000 lb of contaminants between January 1997 and March 1999

Case Study: MCB Camp Lejeune, NC
OU 2 (Cont.)

- Air stripping tower
  - 66 ft high
  - 5 ft diameter
  - 45 ft packing
  - ~ 300 gpm

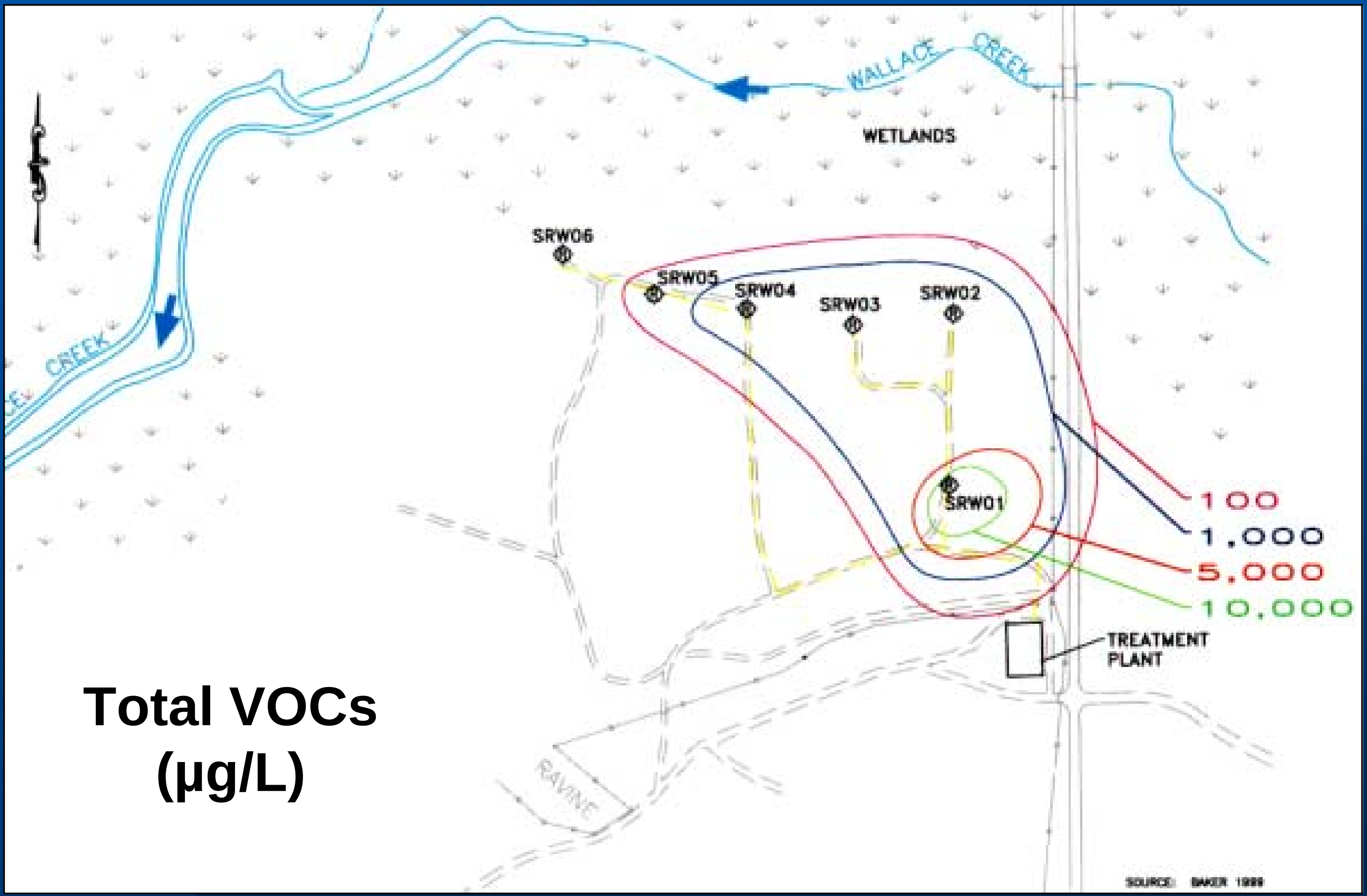
Case Study: MCB Camp Lejeune, NC
OU 2: Deep Plume



Total VOCs (µg/L)

Case Study: MCB Camp Lejeune, NC

OU 2: Shallow Plume



Case Study: MCB Camp Lejeune, NC
OU 2: Recommendations

- Continue P&T and aggressive mass removal
- “Don’t fix it if it ain’t broke”
- Suggest the following when recovery rates decline:
  - Additional site characterization to delineate dense, nonaqueous-phase liquid (DNAPL) source area and dissolved plume
  - Evaluate role of MNA, particularly for shallow zone
  - Use diffusion samplers
    - Selected wells
    - Determine appropriate screen interval for future wells

Case Study: MCB Camp Lejeune, NC
OU 2: Recommendations (Cont.)

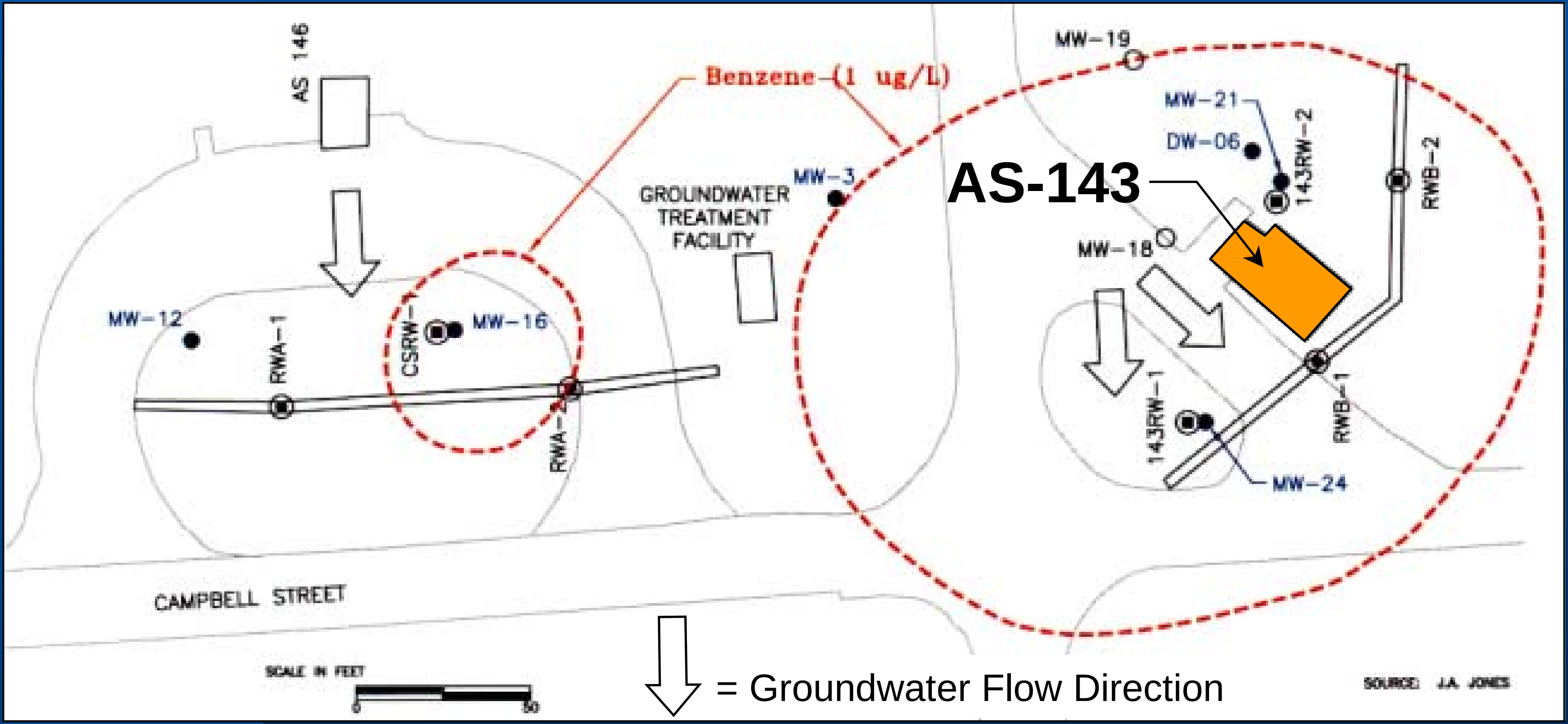
  - Consider revising risk assessment and cleanup levels for industrial land use as future exposure scenario
- Sample individual wells quarterly for COCs
- Prepare time series plots and contours of individual COCs

Case Study: MCB Camp Lejeune, NC
Campbell Street Fuel Farm

Case Study: MCB Camp Lejeune, NC
Campbell Street Fuel Farm

- Three sites
  - Jet propellant 5 (JP-5) and gasoline contamination from tank and pipeline leaks
- Excavated contaminated soil
- Recovery trenches at all three sites, and three recovery wells in hot spots
- Small P&T system (package unit)

Case Study: MCB Camp Lejeune, NC
Plumes at Campbell Street Fuel Farm



Case Study: MCB Camp Lejeune, NC
Campbell Street Fuel Farm: Recommendations

- Evaluate MNA for site closure
  - Additional monitoring wells needed
  - Asymptotic conditions observed
  - Plumes appear to be contained
- Pumping from two sites may be stopped
- Continue with hot spot removal at AS-143
  - May use existing mobile Aggressive Fluid Vapor Recovery system from MCB instead of P&T system

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- RAO and monitoring costs will increase
- Conduct detailed annual evaluation to review progress and to identify optimization opportunities
- Include cost and performance plots, time series plots and other data visualization approaches
- Need exists to improve cost data collection for the annual report

Summary (Cont.)

- Interim Final Monitoring Guidance provides details of how to optimize monitoring
- RAO optimization should consider technology substitution (at technology limits)
- Optimization will reduce long-term costs and provide focus for site closeout
- RAO Optimization Guidance (September 2000)

Tools

- DON Working Group Web site

  http://enviro.nfesc.navy.mil/ps/raoltm/index.html

  – Contains:
    - Optimization Case Studies
    - Interim Final Guide to Optimal Groundwater Monitoring (January 2000)
    - Draft RAO Optimization Guidance (September 2000)
    - Web site links (USAF, Army, EPA, DOE)

- Environmental Site Closeout Process web site

  http://www.afbca.hq.af.mil/closeout/

Points of Contact

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